Section 4
Communication and Tracking Overview

4.1 Introduction

Communications is without question an integral component of the International Space Station (ISS). Without extensive communication with the ground, neither the safe, stable, reliable operation of the Station, nor would the dissemination of scientific research would be possible. The ISS Communication and Tracking System (C&TS) is designed to support these two important functions, Station operations and scientific research. This section provides an overview of the United States On-Orbit Segment (USOS) C&TS and its five subsystems.

4.2 Objectives

After completing this section, you should be able to

- Describe the major functions and operations of the Communication and Tracking (C&T) Subsystems
- Describe the capabilities, constraints, and redundancies of the C&T Subsystems
- Describe how C&T Subsystems interface with other ISS systems
- Describe Russian Orbital Segment (ROS) C&T capabilities

4.3 Purpose

The purpose of the C&TS is to provide

- Two-way audio and video communication among crewmembers onboard the Station, including Extravehicular Activity (EVA) crewmembers
- Two-way audio, video, and file transfer communication with Flight Control Teams located in the Mission Control Center-Houston (MCC-H) and payload scientists on the ground
- One-way communication of experiment data to the Payload Operations Integration Center (POIC)
- Control of the Station by flight controllers through the reception of commands sent from the MCC-H and remotely from the orbiter
- Transmission of system and payload telemetry from the ISS to MCC-H and the POIC

4.4 Overview

The C&TS is divided into six subsystems: the Internal Audio Subsystem (IAS), the S-Band Subsystem (S-band), the Ultrahigh Frequency (UHF) Subsystem (also known as the Ultrahigh Frequency Communication System (UCS)), the Video Distribution Subsystem (VDS), the Ku-Band Subsystem (Ku-band), and the Early Communication Subsystem. Figure 4-1 shows the six subsystems and their interfaces with each other, with the Command and Data Handling (C&DH) System, and with other external entities necessary to achieve the C&T functions. The Early Communication Subsystem is not part of this section because it is a temporary subsystem that will be dismantled during assembly Flight 6A. See Appendix A for Early Communication Subsystem information.

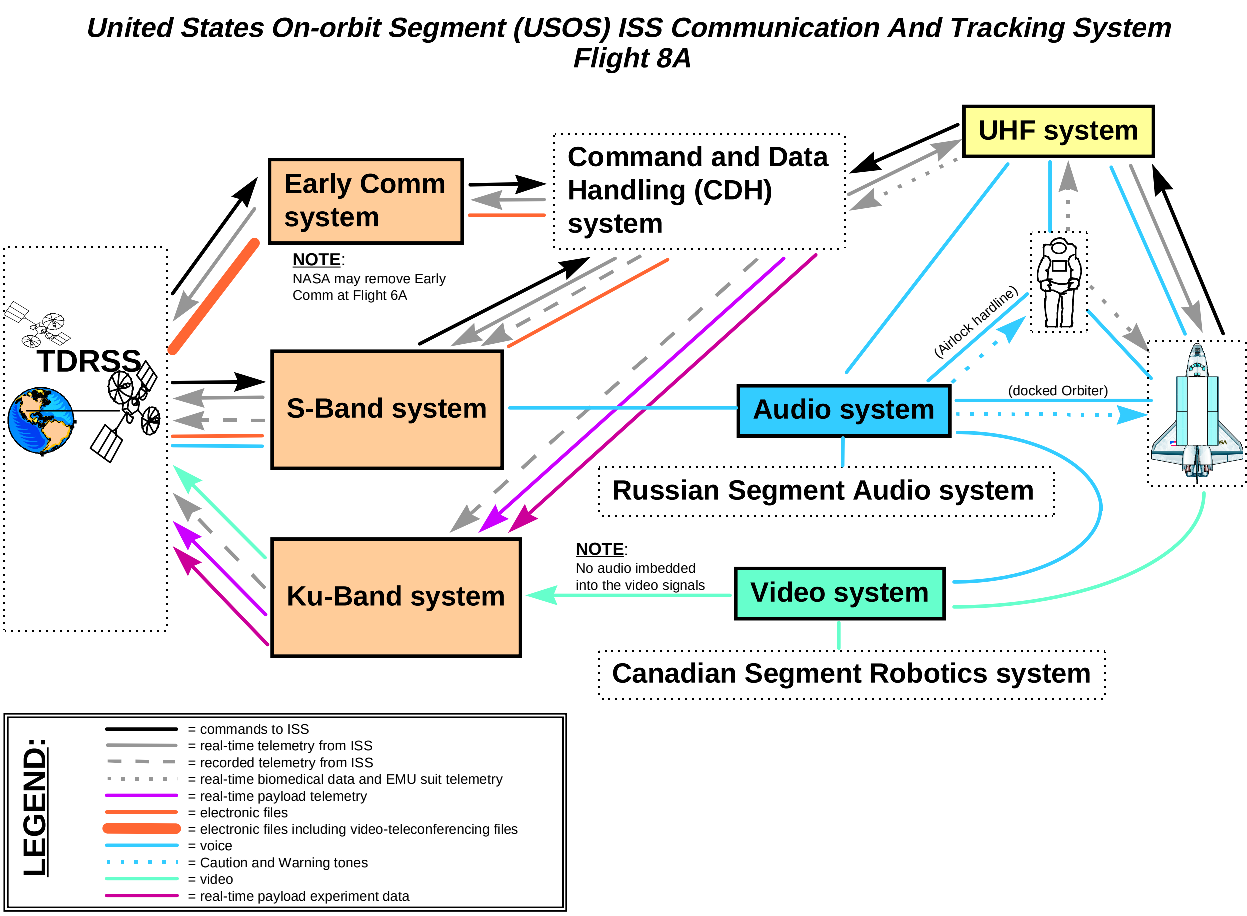

Figure 4-1. C&T System overview

As illustrated in Figure 4-1, all the USOS C&T Subsystems work together to provide the communication services needed by the USOS to carry out the mission of the ISS. ***The S-Band Subsystem transmits voice, commands, telemetry, and files. The IAS distributes audio onboard the Station and to external interfaces. The VDS distributes video onboard the Station and to external interfaces, including the Ku-band for downlink. The UHF Subsystem is used***

for EVA and proximity operations, while the Ku-Band Subsystem is used for payload downlink and video and file two-way transfer.

The National Aeronautics and Space Administration (NASA) is studying plans to add to the Ku-Band Subsystem the capability to transfer commands and data between the ground and the USOS and also to add two-way transfer of video and associated voice between the USOS and the ground. This capability will provide a backup to the S-band capability.

Before the five C&T Subsystems and the Russian-equivalent systems are explained in Sections 4.2 through 4.6, it is important to understand the one important aspect of the C&TS that deals with transmission of external commands.

4.4.1 ISS Commanding

As previously stated, operating the USOS and controlling the ISS is a vital function supported by the C&TS. This is done through an MCC-H-to-Station link for commanding the Station and a Station-to-MCC-H link for sending telemetry from the Station. MCC-H is the determining center for commanding the USOS. Figure 4-2 shows the command paths to the Station operating systems through the U.S. Communication Subsystems only.

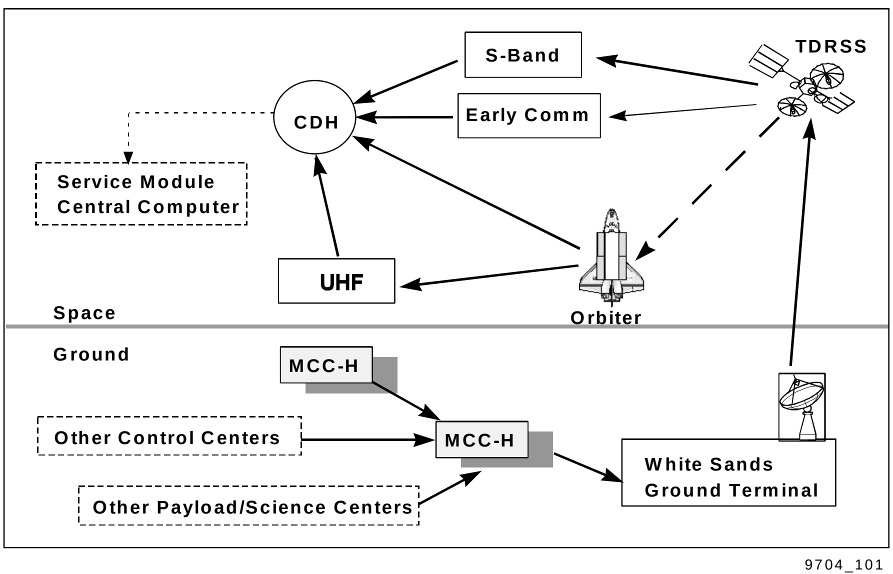

Figure 4-2. USOS command paths

Notice that the Early Communication, S-band, and UHF Subsystems are the C&T subsystems that can transport commands to the USOS. Commands can also reach the Station through a docked orbiter and through the ROS communication Subsystems. Mission Control Center-Moscow (MCC-M), European Space Agency (ESA), and National Space and Development Agency (Japan) (NASDA) control centers can command the ISS through MCC-H. Also, payload control centers can command payloads and some ISS equipment through the POIC and MCC-H.

Operational system telemetry and critical payload telemetry from the Station to MCC-H also use the same paths as the commands, but in the reverse direction, using the S-band and Early

Communication Subsystems (not UHF). It should be noted that communication availability (coverage) for the ISS is not as plentiful as the orbiter's coverage. The orbiter has approximately 90 percent communication availability when using two Tracking and Data Relay Satellites (TDRSs). ***However, because of the signal blockage caused by the ISS itself, USOS C&T coverage is approximately, on average, 50 percent.*** Some orbits are less than 50 percent, while others are more. Flight controllers use ground tools during mission and real-time planning to help choose the optimal TDRS pairs that provide for the best coverage.

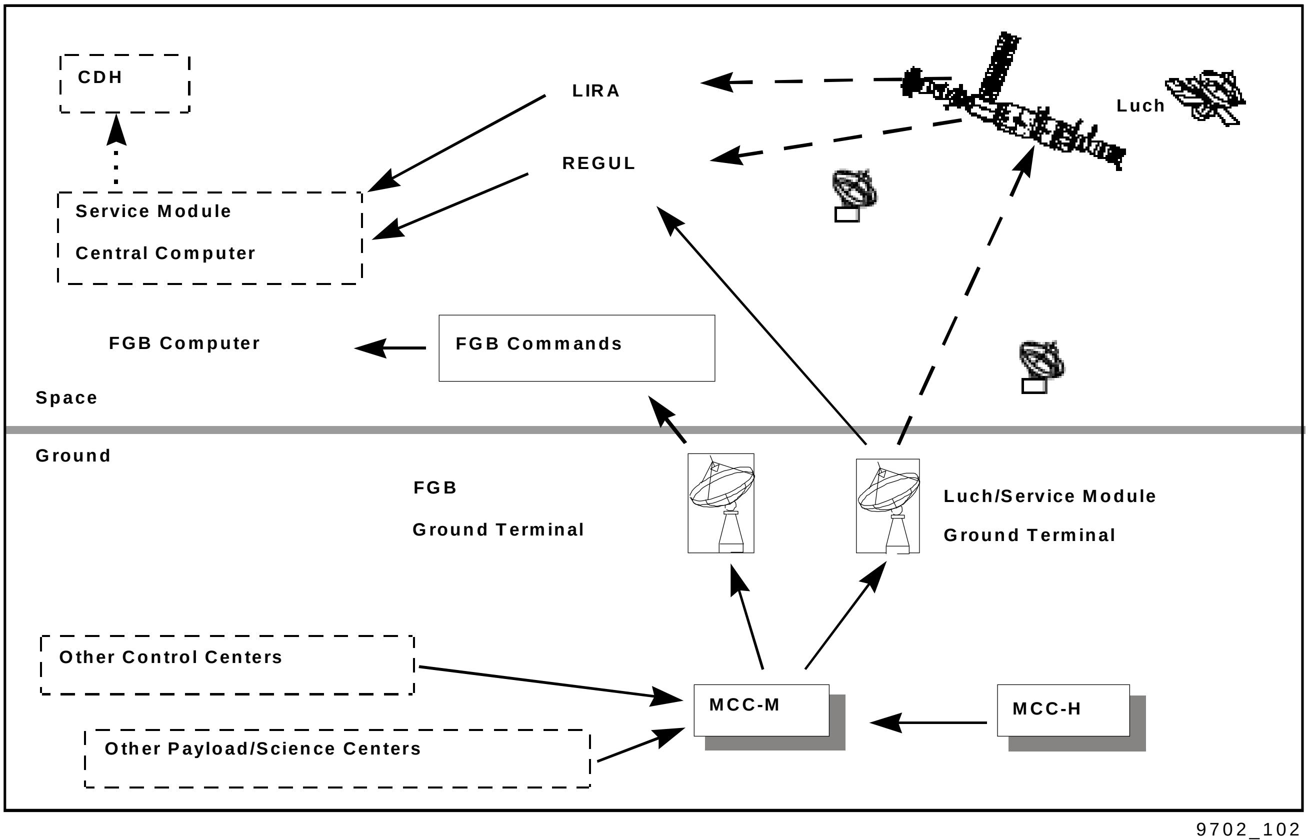

Figure 4-3. Russian Segment command path

The ROS command path is illustrated in Figure 4-3. Commands can be shared between the two segments through the C&DH Command & Control Multiplexer/Demultiplexer (C&C MDM). ***Notice that the ROS communication Subsystems can receive commands directly from ground stations through the Regul Subsystem and can receive commands from the LUCH satellite through the Lira or the Regul System.*** Telemetry from the ROS follows the same paths as commands, but in the opposite direction. Notice that the commanding function can be initiated from either control, MCC-H or MCC-M. Additional commanding may occur through other control and payload centers, when appropriate.

Russian communication coverage is nearly continuous while using Russian ground stations. However, these stations are available only for a portion of an orbit. The LUCH satellite coverage is approximately 45 minutes per orbit.

This explanation of command and telemetry paths and capabilities provides a background for understanding the functions and operations of the five C&T Subsystems that follows.

4.5 Internal Audio Subsystem

Notice in Figure 4-4 that the IAS interfaces with the S-band, UHF, and VDS Subsystems (through the Video Tape Recorders (VTRs)). The IAS is pivotal to understanding the way the C&T Subsystems work together to provide the communications necessary for mission success.

4.5.1 IAS Purpose

The purpose of the IAS is to distribute voice and Caution and Warning (C&W) tones onboard the ISS. This includes distributing those signals to other subsystems for further distribution, both internally to ISS (Russian Service Module (SM)) and externally to the orbiter, ground, and EVA crews. Later, the IAS is the primary means of distributing audio between the USOS and other International Partner modules, such as the Japanese Experiment Module (JEM) and the Columbus Orbital Facility (COF).

Reliable electronic conversation among physically separated crewmembers is essential for their safety and the success of their flights or missions. ***The IAS acts as the "intercom," and telephone system for the pressurized elements in the U.S. Segment to support this function.*** An interface with the SM allows for whole Station communications to support multi-element and multi-segment operations.

The IAS link with the USOS UHF Subsystem allows the crew to communicate with an EMU-suited EVA crew (while in the Joint Airlock and during an EVA) and with an orbiter crew during approach and departure. Hardline connections allow direct voice and C&W communication with the shuttle crew in a docked orbiter. Also, the IAS provides two-way air-to-ground voice, using the USOS S-band Subsystem. Finally, the IAS connects with the USOS VDS's VTRs to record and playback audio.

Perhaps the most important of all the IAS functions is the IAS's ability to inform the crew audibly of a C&W event. This capability is crucial to the safety of the crew and the condition of the ISS and its equipment.

4.5.2 IAS Operations and Components

Most of the signal routing and malfunction recovery for this subsystem are automated and, therefore, do not require crew or controller intervention. Flight controllers operate the subsystem occasionally to perform activation and checkout, troubleshooting, and some voice loop setup to offload the crew. The crew however, performs most of the configuration for the IAS at an Audio Terminal Unit (ATU). This includes making calls, joining conferences, and setting the volume, as needed. Establishing an air-to-ground conference requires commands to the IAS from a Portable Computer System (PCS) or the ground to configure the interface unit between the IAS and the S-band Subsystem.

The IAS consists of the following types of Orbital Replacement Units (ORUs): Internal Audio Controller (IAC); ATU; Audio Bus Coupler (ABC); and three types of audio interface units: the Assembly-Contingency/UHF Audio Interface (AUAI), the Docked Audio Interface Unit (DAIU), and the Russian Audio Interface Unit (RAIU). Figure 4-4 contains a simple schematic of this subsystem. The following subsections discuss these components.

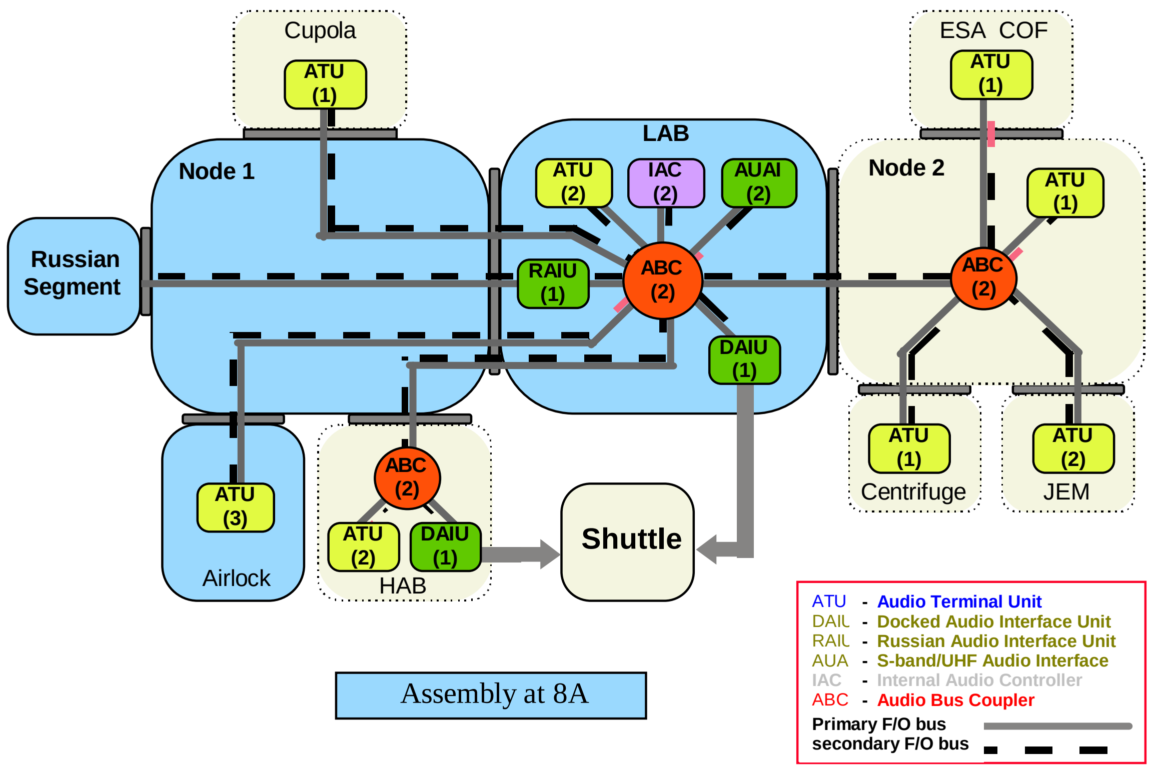

Figure 4-4. Internal Audio Subsystem overview

4.5.2.1 Internal Audio Controller

The IAC acts as the IAS switchboard for all of the calls made at the ATUs. It manages the IAS by automatically routing calls, C&W tones, and commands and status. Also, the two redundant IACs are the only interface of the IAS to the C&C MDM via the 1553 bus. Losing both IACs causes the loss of all U.S. Segment audio capabilities.

The IAC plays a key role in C&W events. ***When the C&C MDM detects a failure (including in the ROS), it sends a message to the IAC to annunciate a caution, warning, or emergency tone.*** The IAC, in turn, generates and sends these tones to the ATUs for broadcast through their speakers. ***There is no direct C&W interface between the USOS IAS and the ROS Telephone and Telegraph Communication (TTC) System.*** All messages to send C&W tones from one segment to the other must go through the U.S. Segment C&C MDM and ROS SM Central Computer.

4.5.2.2 Audio Terminal Unit

The ATU acts as the crewmember's telephone. Its capabilities are similar to that of a typical office telephone. As shown in Figure 4-5, the ATU has a microphone, a speaker, and a keypad. ***The crew can use the ATU to do the following: listen in on five different conferences; talk on one of the conferences; call another location directly and exclusively (e.g., another ATU, the ground, the UHF Subsystem); and initiate a page for a crewmember. The ATUs also annunciate C&W tones.*** The multiple ATUs can support conversations involving multiple crewmembers on the ISS.

Each ATU is zero-fault-tolerant. However, the ATUs are interchangeable. By performing in-flight maintenance, the crew can replace one ATU with another (13 total at Assembly Complete (AC)). Even if there are no spare ATUs, the crew could replace a malfunctioning ATU in an often-used location with an ATU from a rarely-used location.

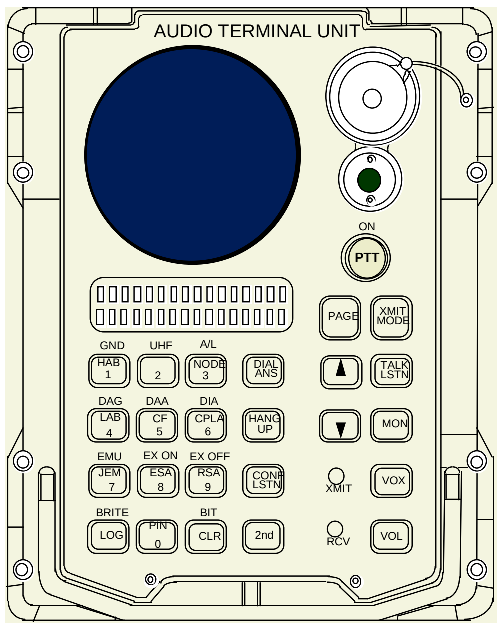

Figure 4-5. Audio terminal unit

4.5.2.3 Audio Bus Coupler (and Bus Network)

The ABCs provide the coupling of the different lines of the digital fiber-optic audio bus network. This bus network is the medium for the transport of the audio signal, including command and status signals, for all of the IAS ORUs.

There are two fully-redundant fiber-optic digital audio buses. Each bus has its own ABC at each juncture (see Figure 4-4), so there are two redundant strings of the audio bus network. Each ATU, each IAC, and the interface units are attached to both buses. Of course, losing both audio buses causes the loss of all U.S. Segment audio capabilities.

4.5.2.4 Interface Units

The IAS has many interface units that allow audio connectivity to other audio systems. ***The AUAI is the connection to both the EVA crew, via the UHF Subsystem, and to the ground, via the S-band Subsystem. The DAIU is the interface between the USOS and a docked orbiter. The RAIU is the connection between the USOS and the ROS and is the interface to the VTRs.*** Both the DAIU and the RAIU must convert audio signals from digital (IAS) to analog (orbiter and ROS) and vice-versa.

There are two AUAIs. Each AUAI is an interface between the IAS and one UHF Subsystem string and the two audio channels of one S-band Subsystem string. They therefore form two redundant strings of space-to-space and space-to-ground communications.

There is only one DAIU (at 8A) and only one RAIU. These two interface units are, however, interchangeable. If a DAIU or RAIU fails, the crew can reestablish lost capability by performing in-flight maintenance to exchange them. At AC, there are two DAIUs. At that point, one DAIU is used when the orbiter docks to PMA2 and the other when the orbiter docks to PMA3.

4.5.2.5 Application Software

The C&C MDM, through the IAS application software, controls and monitors the IAS through the IAC. The C&C MDM sends commands to the IAC, which then routes the commands to the IAS ORUs. In the reverse direction, each IAS ORU sends its status to the IAC, which then routes the status to the C&C MDM. If there is an IAC failure, the software automatically commands a switch to the redundant IAC so that there is no interruption of service. It is especially important for C&W tone capability not to be interrupted. While there is one 1553 bus connection to each IAC, there is dual redundancy in that each bus connection has two channels (A and B).

4.5.3 Russian Audio

The ROS TTC Subsystem provides hardwire audio capabilities between all Russian modules. It also has an interface to the USOS IAS via the RAIU. The TTC System provides voice, paging, and C&W communications capability for crewmembers. This system receives and records telegraph information over the VHF-1 channel (space-to-ground), VHF-2 (space-to-space), and through the Regul and Lira Systems. The telephone Subsystem supports six Audio Communication Units (ACUs) in the SM and two ACUs in the Functional Cargo Block (FGB). Each ACU has two headsets with individual volume controls and push-to-talk buttons. They also have a dynamic (vox) mode with built-in microphones. The TTC System is analog, while the IAS is digital. Also, the conferences for the TTC System are hard-wired, while the conferences for the USOS are multiplexed and reconfigurable. The TTC Subsystem uses simplex communications while the IAS uses duplex communications.

Table 4-1 shows the expansion of IAS Subsystem capabilities during assembly of the ISS.

Table 4-1. Internal audio subsystem assembly sequence

Flight	Hardware	Capability
5A	IAC-1, IAC-2, LAB ATU-1, LAB ATU-2, DAIU-1, AUAI-2, LAB ABC-1, LAB ABC-2	First capability of the U.S. Audio System. The AUAI-2 provides the first air-to-ground capability via ISS Audio System. Also, provides ability to communicate to the orbiter via the U.S. Segment
6A	RAIU-1, AUAI-1, CUPOLA ATU-1	The RAIU provides the Audio interface between the ROS and the U.S. Segment. The Cupola ATU will be used as a spare until the Cupola is attached
7A	AIRLOCK ATU-1, EMU ATU-1, EMU ATU-2	First capability of Station-based EVAs with EMUs
10A	NODE 2 ATU-1, NODE 2 ABC-1, NODE 2 ABC-2	Additional ATU
1J/A	JEM ATU-1, JEM ATU-2	Additional ATUs
1E	APM ATU-1	Additional ATU
UF7	CAM ATU-1	Additional ATU
16A	HAB ATU-1, HAB ATU-2, DAIU-2, HAB ABC-1, HAB ABC-2	Additional ATUs and DAIU

4.6 S-Band Subsystem

The IAS's interface with the S-band Subsystem is the primary means of transferring audio to and from the Station and the ground. These two subsystems work together to provide ISS audio communication, a central function of the C&TS. The S-Band Subsystem was once called the Assembly/Contingency System (ACS). This acronym can still be found in S-band documentation today.

4.6.1 Purpose

The S-Band Subsystem is the communication system that is used for primary Command and Control of the ISS. The ROS Communication System is used for backup command and control. However, MCC-M will command the ROS systems, coordinating with MCC-H concerning those commands that effect the USOS and the ISS as a whole.

The S-Band Subsystem transports commands from the MCC-H and the Payload Operations Integration Complex (POIC) to the ISS and transports USOS System and critical payload telemetry from the ISS to MCC-H and POIC. Telemetry data can be "real-time" or recorded telemetry data. The S-band also is used for two-way audio and file transfer between the ground and the ISS. The audio can be "real-time" or recorded. Selected FGB and ROS system telemetry are also transferred to the ground through the S-Band System.

4.6.2 S-Band Components and Operations

The S-Band Subsystem consists of three ORUs (see Figure 4-6, S-band overview). They are the Baseband Signal Processor, the Standard TDRSS Transponder, and the Radio Frequency (RF) Group, including a steerable and an omni-directional antenna. The S-Band Subsystem operates in a zero-fault-tolerant condition on truss segments Z1 and P6 until 9A, when a second complete S-Band Subsystem is brought up to the Station on truss segment S1 and becomes operational. At 1J/A, the Z1/P6 string is moved to its permanent location on truss segment P1. ***There is no cross-strapping, or connection, between the two S-band strings.*** The S-band can be operated in a degraded mode, such as, a loss of one channel of audio or one of the antennas.

The S-band Subsystem transmits and receives at a High Data Rate (HDR) of 192 kbps return link, and 72 kbps forward link, and a Low Data Rate (LDR) of 12 kbps return and 6 kbps forward. There is no audio transmission in LDR. Flight controllers in MCC-H perform the primary role in operating the S-Band Subsystem. The crew acts as a backup to the flight controllers under certain Loss-of-Signal (LOS) conditions. For nominal operations, some of the duties of a flight controller may include activating or deactivating the system, checking it out by running system tests, and making changes to data rates or operational limits of components. These operations are done during major assembly operations, powerdowns, or during maintenance activities. The crew will most likely not participate in these activities other than to confirm onboard indications.

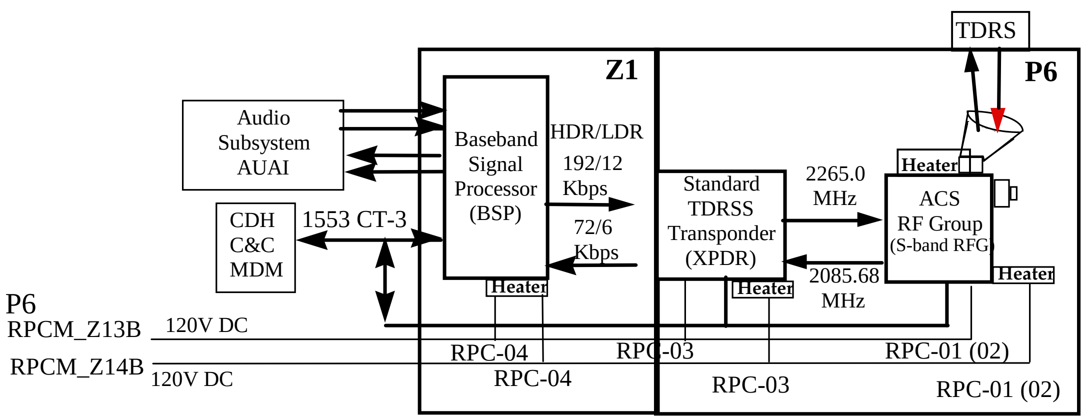

Figure 4-6. S-band overview

As shown above, the S-band interfaces with the Electrical Power System (EPS). Once the Remote Power Controllers (RPCs) are closed, the ORUs perform a Power On-Self-Test and wait for software commands. The EPS also independently powers heaters for these external components.

If there is no interruption of the command link from the MCC-H, failures within the S-band are diagnosed and isolated by MCC-H Flight Controllers. Otherwise, the ground must use the telemetry and command capability of the orbiter, if it is present, or use the Russian partner's communication equipment to isolate or restore the S-band functions. They coordinate with their MCC-M counterpart to command the system, and for that matter, the Station, from the

MCC-M. Also, after an S-band failure where the command link is lost, the crew becomes an important asset in trying to reestablish S-band communication.

4.6.2.1 Baseband Signal Processor

For the return link (the communication path from the Station to TDRSS and then to the MCC-H), the Baseband Signal Processor (BSP) does what the name infers, processes telemetry packets sent from the C&C MDM over the 1553 bus. ***It resegments the telemetry packets into Channel Access Data Units (CADUs), which are Reed-Solomon (R-S) encoded and sent to the transponder at 192 kbps.*** R-S encoding ensures that the ground receives nearly error-free data. On the forward link, or uplink, ***the CADUs created on the ground, are decoded, and most transmission errors are fixed in the R-S decoder. In addition, the forward data, encrypted on the ground, is decrypted to ensure the safety of the uplinked commands.*** That is, no inappropriate commands can be passed to the C&C MDM. File packets are sent to the BSP in the same way telemetry packets are sent and processed in the same way, both for the return and forward links.

The S-band provides two independent channels of two-way voice between the crew and the ground. The BSP receives two channels of digital audio data from the AUAI unit of the IAS. The audio data is compressed in the BSP. Audio data is then segmented and encoded just as telemetry data and files are. For the forward link, the digital audio data is decoded, decrypted, and decompressed before being clocked into the AUAI of the IAS for distribution onboard. Two-way audio is available in HDR only.

The C&C MDM interface over the 1553 bus is also used for commands from the S-band application software to the BSP. It is also used by the software to extract status from the BSP to be passed to the C&C MDM Common Value Table to be turned into telemetry. ***Notice in Figure 4-6 that the 1553 bus is connected to the transponder and the Radio Frequency Group (RFG), too. This connection is used for ORU commanding and status. It is not used for command and telemetry CADU transportation.***

4.6.2.2 Transponder

The transponder is the ORU that creates a radio signal and modulates that signal corresponding to the digital data pattern from the BSP. The transponder sends the modulated radio signal to the RFG. ***Inversely, the transponder receives the radio signal from the RFG, demodulates the signal and recreates the digital data per the modulation pattern.*** It sends this data to the BSP at 72 kbps for the HDR mode. These signals are not transported over the 1553 bus, but by an RS-422 cable. The 1553 bus is connected to the transponder to send commands to the ORU and extract status from the transponder to be sent back to the C&C MDM.

4.6.2.3 Radio Frequency Group

For the return link, the RFG receives an RF signal from the transponder, amplifies it, and broadcasts the RF signal through the High Gain Antenna (HGA) or Low Gain Antenna (LGA) to the TDRS, which in turn communicates with the MCC-H via the White Sands Ground Station (WSGS). ***On the forward link, the RFG antenna (either HGA or LGA) receives a***

signal from the TDRS and sends the signal to the transponder for demodulation. The signals to and from the transponder are not transported over the 1553 bus, but by an ROS-422 cable. The 1553 bus is connected to the RFG to send commands to the ORU and extract status from the RFG to be sent back to the C&C MDM.

The HGA is used for HDR operations, while the LGA is used for LDR operations. The HGA is a gimbaled antenna (moving in azimuth and elevation) that tracks the TDRS as the Station orbits the Earth. The HGA is commanded to the correct position by the S-band application software. The LGA is an omni-directional antenna. Loss of the HGA antenna is a significant loss since that antenna is used for HDR transmission. In that case, either the Early Communication System (until 6A) or the ROS communications equipment is used.

4.6.3 Software

Fortunately, the S-band can operate semi-automatically. This is due to the S-band application software that resides in the C&C MDMs. This software issues appropriate alarms based on detected out-of-limits conditions from the status data sent to it from the S-band components. ***It also detects LOS conditions and may issue commands to automatically switch to another S-band string or to a LDR service.*** It is the flight controller’s duty to enable this automated Fault Detection, Isolation, and Recovery software capability.

There is another software application pertaining to S-band called Extended Loss of Communication (ELOC). ***This application is another routine to regain communication when there has been an extended period of time without commanding ability to the Station.*** This routine is initiated when a timer, that is reset by an MCC-H Flight Controller command, expires.

The C&T software has an interface with the GNC software for HGA pointing data. The GNC software calculates the position of the HGA in regard to the Tracking and Data Relay Satellite System (TDRSS) and passes those coordinates to the S-band software, which in turn, recalculates the angles for the antenna. It sends those coordinates to the RFG antenna controller to point the antenna.

4.6.4 Comparable Russian Segment Communication Systems

4.6.4.1 Regul System

The ROS equivalent to the S-band is the Regul System. Before telemetry reaches the Regul System, data is collected onboard the ROS, using the Onboard Measuring Subsystem. This system is divided into two parts. The Onboard Data Telemetry System and the Transit-B System.

The Regul System is designed for two-way voice communication, digital command/program information, as well as telemetry transmission to Russian ground stations or the LUCH satellite. It also has the capability to receive and transmit range and velocity information, as well as time-referenced signals. The Regul System is comprised of three transmitter/receivers, three digital processing units, two directional finders, and an exchange adapter to talk to the Onboard Complex Control System (OCCS). It also has an omni antenna (standby mode) when communicating with the ground stations and a phased array antenna (active mode) when communicating with the LUCH. The system can operate in both the active and standby modes simultaneously.

4.6.4.2 Telephone and Telegraph Communication Subsystem

The Russian TTC Subsystem provides duplex radio communication over the VHF-1 (space-to-ground) channels for space-to-ground audio communication to Russian ground stations or through the Regul (LDR) or Lira (HDR) Systems when a relay satellite is used. This is comparable to the S-band capability to transmit audio to the ground. Audio collected from the space-to-space VHF-2 Subsystem (UHF equivalent) can be retransmitted to the ground, LUCH satellite, or recorded onboard using this system.

Table 4-2 shows the expansion of S-band Subsystem capabilities during assembly of the ISS.

Table 4-2. S-band assembly

Flight	Components	Expansion details
3A	BSP, RFG in the Z1	Heaters only, one for BSP, one for RFG
4A	Transponder on P6	RFG moved to top of P6; S-band operational in LDR only. Each ORU heater operational
5A	Lab with C&C and S-band SW	HDR operations; two-way voice, files, command, and telemetry. ZOE recorder playback
9A	S1 installed with S-band string S1	S1 string operational and P6 string operational; one fault tolerant
13A????	P1 installed	P6 string moved to P1; becomes string P1

4.7 Ultrahigh Frequency Subsystem

The ISS UCS is one of the subsystems of the Space-to-Space Communication System (SSCS) and operates in the UHF frequency range. The other parts of the SSCS are the orbiter and Extravehicular Mobility Unit (EMU) space-to-space UHF Subsystems. The UCS, commonly referred to as the UHF Subsystem or UHF, provides the SSCS link for the ISS.

4.7.1 Purpose

The purpose of the Station UHF Subsystem is to provide for space-to-space communication in and around the ISS when hardline communication is not possible. ***This space-to-space communication is between the ISS and the orbiter for voice, commands, and telemetry; EVA-suited crewmembers for voice, biomedical, and EMU data; and to accommodate future Free Flyer (FF) payloads for commands and telemetry.***

4.7.2 Ultrahigh Frequency Subsystem Operations and Components

The UHF Subsystem is designed to support up to five simultaneous users. It is a digital data system operating on a RF network. It consists of a Space-to-Space Station Radio (SSSR), enclosing two transceivers, two sets of external double antennas, and internal antennas that are found in every USOS habitable module. (See Figure 4-7, UHF Subsystem overview).

The UHF Subsystem supports not only traditional EVA functions of voice, EMU, and biomedical data transmission, ***it also supports the space-to-space transmission of commands and telemetry. This is used during rendezvous and docking operations when the Station must be configured remotely.*** The orbiter sends commands to the ISS UHF Subsystem, which passes them to the C&C MDM for execution. The ISS UHF returns only telemetry data. FFs (remotely controlled vehicles) use the UHF Subsystem for approach and docking too. However, with FFs, the ISS sends commands to the FF through the UHF Subsystem and receives telemetry. The European ATV is such a vehicle.

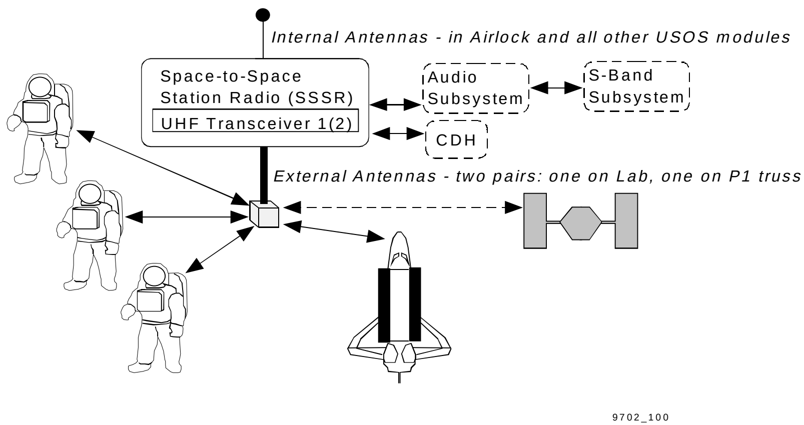

Figure 4-7. UHF Subsystem overview

The UHF Subsystem can be operated by the crew or by flight controllers. Flight controllers can configure the system or run system tests by commands sent to the Station. These commands are sent via the ISS S-band or the shuttle OIU to the C&C MDM and then to the UHF radio. The ground also supports UHF troubleshooting. The crew uses the Portable Computer System (PCS) laptop to command the UHF Subsystem and verify power modes.

4.7.2.1 Space-to-Space Station Radio

The SSSR consists of one ORU, containing two transceivers. Both transceivers are contained in one housing and are serviced by one coldplate; but, each is powered by separate EPS RPCs. Similar to RF systems, the SSSR transceivers (radios) consist of a 1553 module that receives and transmits commands and telemetry from and to the C&C MDM. The SSSR also formats digital audio and multiplexes it with 1553 data and sends it to the internal modem. The modem R-S encodes the data and turns the data into an RF signal that is amplified before it is sent to the antennas for broadcast. Conversely, the SSSR amplifies and demodulates the received signal. The modem decodes and decrypts the data. ***The signal is then processed to separate the audio***

data from the commands or EMU data. It sends the commands and EMU data to the C&C MDM over the 1553 bus. It sends the digital audio to the IAS AUAI for distribution internally through the IAS and externally through the same AUAI to the S-band, which transports the voice to the ground. The loss of both transceivers in the ORU results in loss of all UHF Subsystem RF communications for the Station. ***A fire in one rack could destroy both radios.***

4.7.2.2 UHF External Antennas

The UHF external antennas consist of two pairs of antennas mounted on the U. S. Lab Module and truss of the ISS. The antennas are designed to receive signals up to 7 kilometers away. For EVA activity, communication availability provided by these antennas is nearly 100 percent (with all four antennas functional). If the orbiter is present, the orbiter UHF Subsystem can also communicate with the EVA crew. The IVA crew communicates with the EVA crew via the IAS AUAI and the UHF Subsystem. The loss of an external antenna lowers the ability to transmit and receive in that antenna's range. With a loss of one Station external antenna, 25 percent of coverage is lost.

4.7.2.3 UCS Internal Antennas

The UHF Subsystem also supports the periods before and after EVA operations. Before the EVA crewmembers unplug from the EMU Audio Control Panel (EACP) and open the airlock hatch to egress the Station, ***the USOS EMU-suited crewmembers can communicate using the Airlock antenna while still in the airlock.*** They can also communicate with each other in the airlock when they return to the airlock completing the EVA or plug back into the EACP.

The UHF Subsystem not only supports EVAs occurring external to the ISS, ***but also EVAs occurring within a depressurized Station module.*** The internal antennas consist of an Intravehicular Antenna Assembly (IAA) and the Joint Airlock antenna. The IAA's antennas are located throughout the U.S. pressurized modules. This capability is necessary to carry out repairs and restore nominal ISS operations.

4.7.2.4 UHF Internal Antennas

A lesser know function of the UHF is the ability to support EVAs occurring internal to the modules. This function is necessary to carry out repairs in a depressurized module and restore serviceability to the ISS.

The internal antennas consist of an Intravehicular Antenna Assembly (IAA) and the Airlock antenna. The IAA is located throughout the U. S. pressurized modules and is used when an EVA is needed within the Station. The Airlock antenna is used when the EVA crewmember first unplugs from the EVA Audio Control Panel (EACP) and is ready to egress the Station through the airlock. Voice, biomedical, and EMU communication is thus uninterrupted. If the Airlock antenna is lost, the EVA crew must connect to the EACP to communicate.

4.7.3 UHF Software

In the case of UHF Extended Loss of Communication (ELOC), an auto recovery command is issued by the UHF application software located in the C&C MDM. The crew may also execute manual recovery procedures. The autorecovery command swaps transmission from one transceiver to the other transceiver. This autorecovery routine is initiated by an expiration of a timer.

4.7.4 Comparable Russian Segment Communication Systems

The Russian VHF System is analogous to the U.S. UHF Subsystem. ***The VHF-2 channel is part of the TTC Subsystem (see IAS subsection) and is used primarily for space-to-space communication.*** Communication with the EVA cosmonauts is via the VHF-2 channel. The VHF-2 also uses duplex as well as simplex audio communication that occur between the Station and approaching manned vehicles. This voice communications link can also be routed directly to the ground through the VHF-1, Lira or Regul voice channels, or can be recorded to a voice recorder for playback at a more convenient time.

The Transit Autonomous Radio System is used for the spacesuit parameters and control during egress into space and consists of the Transit-A System contained in the cosmonauts spacesuits and the Transit-B System in the SM. This system is part of the Onboard Measuring Subsystem.

Table 4-3 shows the expansion of the UHF Subsystem capabilities during assembly of the ISS.

Table 4-3. UHF subsystem

Flight	Component	Capability
5A	U.S. Lab with C&C MDM	SSSR with two transceivers; check-out of SSSR
6A	One set of antennas installed on Lab	Can support orbiter-based EVAs
7A	Airlock with internal antennas	Can support ISS-based EVAs
11A	Second set of external antennas	Can support whole Station, ISS-based EVAs

4.8 Video Distribution Subsystem

The VDS, as shown in Figure 4-8, also has an interface with the IAS through the VTR. Any audio on the audio bus can be recorded on the VTR and played back to the audio bus for redistribution. The VTR, of course, can record and playback video. ***It is important to know that the ISS routes video and audio separately.*** Video and audio are also sent to the ground via different paths. Audio and its associated video are resynchronized on the ground.

4.8.1 Video Distribution Subsystem Purpose

The purpose of the VDS is to distribute video signals onboard the U.S. Segment of the ISS. It also interfaces with other International Partner (IP) Video Subsystems. The sources of this video are external cameras, internal cameras, recorders, and payload rack cameras. The possible destinations are internal monitors, recorders, payload rack recorders, a docked orbiter, and the ground through the Ku-band. The video signals are distributed by fiber-optic analog video lines.

The external cameras, both on the ISS structure and on the robotics equipment, act as valuable tools for the external operations of robotics and EVA, especially for ISS assembly and maintenance. ***The robotics operator cannot operate the Space Station Robotics Manipulator System (SSRMS) without the camera views provided by the ISS VDS.*** Certain payload experiments use internal cameras to investigate and record the results of experiments. Video-conferencing also uses the internal cameras of the VDS. ***As with the orbiter, sending any ISS video signals to the ground requires routing through the Ku-Band Subsystem.***

4.8.2 Video Distribution System Operations and Components

For both external and internal cameras, both the crew and flight controllers can operate the subsystem. Typically, flight controllers always power up and power down the subsystem ORUs and operate the subsystem when it is used for operations involving payload data, for any recorded video, and for troubleshooting. Crewmembers typically operate the subsystem when it involves external operations. This includes routing a video image to an internal monitor, focusing, iris open/close, and pan and tilt.

Instead of being set up as different strings, the VDS redundancy scheme is that all components are attached together. While the loss of a single component does not make the subsystem unusable, the subsystem does lose capability. For example, if a certain external camera port were to fail, the subsystem could continue to operate, but a camera view from that specific location would be lost.

The VDS uses the following components: Robotics Workstation (RWS), Common Video Interface Unit (CVIU), Internal Video Switch Unit (IVSU), External Video Switch Unit (EVSU), Sync and Control Unit (SCU), internal camera port, external camera port, robotics Power/Data Grapple Fixture (PDGF), External Television Camera Group (ETVCG), VTR, Video Baseband Signal Processor (VBSP), and International Standard Payload Racks (ISPRs). Figure 4-8 contains a simple schematic of the VDS at the completion of Assembly Flight 8A. Not all of these are part of the VDS. These components are interconnected rather than set up as “strings.”

The following subsections briefly discuss these components. Section 2 of this document discusses the components in more detail.

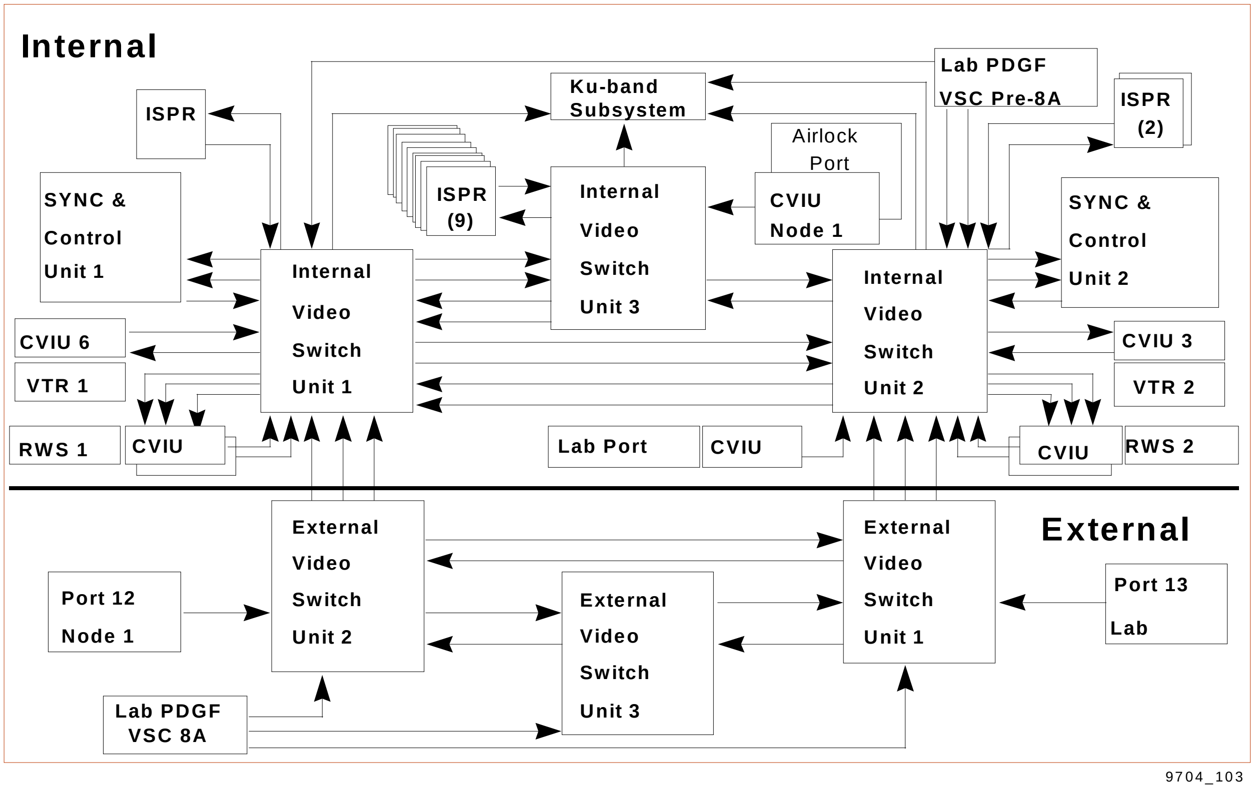

Figure 4-8. Video Distribution Subsystem overview

4.8.2.1 Robotics Workstation

The RWS, which is part of the Robotics System, is where crewmembers typically operate the SSRMS. Since robotics operations require video, ***the television monitors and the hardware panel for crewmember control of the VDS are located at the RWS.*** Here, the crewmember can route a video image from any camera or VTR to an onboard monitor (located at the RWS), a VTR, or to the ground**.** The crewmember can also operate the external cameras (pan, tilt, focus, etc.) from the RWS. ***All camera commands can also be sent from a PCS or from the ground.***

There are two redundant RWSs. At the time of Assembly Flight 8A, they are both in the Lab Module. Later, one of the two RWSs is moved to the Cupola when it is installed onto the ISS.

4.8.2.2 Common Video Interface Unit

The CVIU is merely the interface between the fiber-optic video line and a component, requiring a conventional copper connection. The CVIU also supplies electrical power to the component so that only one connection to the component is required. There are multiple CVIUs for use with each component that requires video signal conversion.

4.8.2.3 Internal Video Switch Unit and External Video Switch Unit

The Video Switch Units (VSUs), both internal and external, perform the following functions: route video signals, distribute sync signals, and read external camera status from the incoming video signals and send the status to the C&C MDM. At the time of Assembly Flight 8A, there are three IVSUs located in the Lab Module and three EVSUs located on the S0 truss.

4.8.2.4 Sync and Control Unit

The SCU performs the following functions: generates a "house" sync signal for the VDS, generates test patterns, provides the capability to "split-screen" two video images together into one image, provides the capability to perform "time-based correction" of a video signal from a VTR or camcorder, and routes the external camera commands from the C&C MDM to the external cameras. There are two SCUs located in the Lab Module. ***They are redundant except that each can perform one split-screening or one time-base correcting at a time. If one SCU is lost, then the VDS can perform only one of these two functions at a time.***

4.8.2.5 Camera Ports

The ISS has camera ports (part of the Structures and Mechanisms System), both internal and external, for connecting cameras to the ISS. The internal camera ports are for hand-held commercial camcorders. ***The external camera ports (14 in all) are for the ETVCGs***, discussed later. The external camera ports do not include robotics cameras; these are also discussed later. The internal camera ports all have CVIUs to provide video signal conversion and power.

4.8.2.6 Power/Data Grapple Fixture

The PDGF (part of the Robotics System) provides the connection of the SSRMS with the ISS. ***The SSRMS can provide three video signals from cameras on the SSRMS elbow and wrist. The VDS routes these signals the same way that it routes video signals from the internal camcorders and the ETVCGs.*** At Assembly Flight 8A, there is only one PDGF, which is located on the Lab Module. (See Robotics System Training Manual.)

4.8.2.7 External Television Camera Group

The ETVCG contains the externally mounted camera, along with its associated hardware. This associated hardware includes a light source, mechanisms and electronics for panning and tilting, and a converter for converting the video signal to fiber-optic (similar to the function performed by the CVIU). At AC, there are four ETVCGs, but they all arrive at the ISS after Assembly Flight 8A. ***However, there will be at least 14 external camera ports with only the four ETVCGs among them. If an external operation requires a camera view from a certain camera port, and there is no ETVCG at that port, then the ETVCG must be moved via EVA.*** This task takes one EVA crewmember approximately 30 minutes to perform. Note that, because of safety requirements concerning electrical inhibits, some ISS systems (e.g., a S-Band Subsystem string) may require powerdown before moving an ETVCG. Clearly, moving an ETVCG affects more than just the Video Subsystem.

4.8.2.8 Video Tape Recorder

The VTR performs the same functions as those of a commercial VTR. It can record and play back video and audio (audio signals must go through the IAS). ***It can be operated both from the VTR itself or remotely from an onboard PCS or the ground with a manual assist from the crew for putting in and taking out a tape***. At Assembly Flight 8A, there are two VTRs onboard the ISS, one in each MSS rack.

4.8.2.9 Video Baseband Signal Processor

The VBSP (part of the Ku-Band Subsystem) converts the video signal from the fiber-optic format to a digital format to be processed by the Ku-Band Subsystem for transmission to the ground. The Ku-Band Subsystem, subsection of this document, discusses the VBSP in more detail.

4.8.2.10 International Standard Payload Rack

The ISPR (part of the Payloads System) provides a location for payloads on the ISS. ***There are internal video ports in each of the multiple ISPRs to support internal video operations.*** Each payload with video requirements must have its own TV camera or monitor to plug into the ISS-provided port. Video signal conversion from copper to fiber-optic (and vice-versa) is the responsibility of the payload sponsor.

4.8.2.11 Application Software

The C&C MDM, through the VDS application software, controls and monitors the VDS. For video routing, the VDS application software calculates the path for the video signal to take, and the C&C MDM sends the command to the appropriate component. For commanding the ETVCG, the C&C MDM sends commands to the SCU, which then routes the commands to the ETVCGs. In the reverse direction, each VDS component, except for the ETVCG, sends its status to the C&C MDM. The ETVCG sends its status to the VSU, which then routes the status to the C&C MDM. ***If there is a component failure, there is no automatic fault detection, isolation, and recovery.*** All recovery must be commanded.

4.8.3 Russian Equivalent

The ROS Television Subsystem collects video during EVA activities and aids in the control of approach and docking vehicles (both manned and unmanned), using monochrome cameras mounted on the docking ports and on the approaching vehicles themselves. It also receives television video from various modules and displays television pictures on monitors throughout the ROS. The subsystem is capable of digitizing the SECAM signal for transmission of monochrome and color video (with associated audio) to the ground and is able to receive monochrome signals from the ground. This subsystem relies on the ROS's Lira Subsystem for two-way video communications with the ground. Either the crew or ground controllers can operate this subsystem. ***The Television Subsystem is not compatible with USOS National Telemetry/Television Standards Committee (NTSC) signals, and there is no connectivity between the ROS and USOS.***

In addition, the ROS can also transmit analog video directly to ground stations through the SM TV System.

Table 4-4 shows the expansion of the VDS Subsystem capabilities during assembly of ISS.

Table 4-4. Video distribution subsystem assembly sequence

Flight	Hardware	Capability
2A	Node 1 CVIU and camcorder port, Node 1 external camera port	None
5A	IVSU-1, IVSU-2, IVSU-3, SCU-1, SCU-2, camera ports for payload racks, Lab CVIU and camcorder port, Lab external camera port, Lab PDGF VSC	Testing of subsystem only
6A	RWS-1, RWS-2, VTR-1, VTR-2 (all include appropriate CVIUs), VBSP, SSRMS cameras	Can route video from external cameras, robotics cameras, internal camcorders, and payload racks to internal monitors, VTRs, orbiter, and ground
7A	Airlock CVIU and camcorder port,	Can route video from internal camcorder in Airlock
8A	EVSU-1, EVSU-2, EVSU-3	Permanent external connections
9A	4 S1 external camera port, two ETVCGs	Additional external camera views
11A	4 P1 external camera port, two ETVCGs	Additional external camera views
12A	1 P3 external camera port	Additional external camera views
13A	1 S3 external camera port	Additional external camera views
10A	Node 2 CVIU and camcorder port, Node 2 external camera port, IVSU-4	Can route video from internal camcorder in Node 2, additional external camera view, additional routing capability
16A	Hab CVIU and camcorder port, Hab external camera port, IVSU-5, VTR-3, VTR-4	Can route video from internal camcorder in Hab, additional external camera view, additional routing capability, additional recording and playback capability

4.9 Ku-Band Subsystem

As stated in the previous subsection, the VDS has an important interface with the Ku-Band Subsystem. ***It is the Ku-band VBSP. This interface provides for an end-to-end distribution of video from the ISS to the ground.*** The Ku-Band Subsystem is undergoing many design changes to include significant capabilities that were originally envisioned for the subsystem. These upgrades have not been approved by the Station Program at this time; however, when approved, they will make the Ku-band a superior communication system for support of technological operations. These proposed design changes are explained in the following sections.

4.9.1 Purpose

The purpose of the Ku-Band Subsystem is to provide an HDR return link for the U.S. Segment of the ISS. This return link is for real-time payload data, video (real-time and recorded), and recorded ISS systems telemetry (recorded on the Zone of Exclusion (ZOE) recorder). The ISS program has ***added a forward link capability to support the two-way transfer of files and video teleconferencing in support of the CHD System's Operations Local Area Network (LAN).*** These capabilities are implemented during Assembly Flight 6A.

4.9.2 Operations and Components

Experiments and video activity generate enormous amounts of data to be sent to the ground. The capacity of the Ku-band, while large, is limited. ***Flight controllers in the Payload Operations Integration Complex (POIC) configure the Ku-Band Subsystem to accommodate the gigabits of payload data generated per hour. At certain times they must make decisions that reconcile the amount of data generated among many experiments, video, and recorded systems telemetry to the capacity of this subsystem.***

The Ku-Band Subsystem is operated by flight controllers in the MCC-H, as well as the POIC, in coordination with the crew. This includes configuring the subsystem and routing the appropriate data to the subsystem for broadcast. Normally, the antenna pointing is automated.

The MCC-H Flight Controller usually operates the Ku-band when a malfunction occurs. It is their responsibility to troubleshoot, assess, and possibly restore the subsystem's maximum capability. They are also responsible for playing back the recorded USOS systems telemetry (ZOE telemetry) through the Ku-band. This is done usually as a dump of the whole recorder. ***Dumping the ZOE recorder through Ku-band takes minutes as compared to hours through S-band.***

The ISS Ku-Band Subsystem sends 50 megabits per second (Mbps) of serial data to the ground from up to twelve different channels. Subsystem "overhead" is approximately 68 Mbps, so there is about 43.2 Mbps of usable capacity. Up to 4 of the 12 channels can contain video images (one image per channel); however, there is a restriction in that one video channel at a full frame rate (high video quality) uses up almost the entire 43.2 Mbps. The video frame rate often must be decreased to allow downlinking of other data. Up to eight of the channels are reserved for payload data. One of the payload data channels is shared between transmitting recorded telemetry and payload data.

The Ku-Band Subsystem is only single-string. If the VBSP fails, the subsystem still operates, but it has lost the capability to downlink video. If any other ORU fails, the Ku-band capability is lost. Also, structural blockage from the ISS itself greatly impacts the downlink communication availability. ***Ku-band coverage for the ISS is much lower than the Ku-band coverage for the orbiter, approximately 70 percent per orbit, on average.***

There are several other enhancements being considered for this subsystem, post 8A. One enhancement is to ***increase the downlink data rate from 50 Mbps to 150 Mbps.*** Another enhancement is ***to add a Communications Outage Recorder (COR) for recording payload data.***

Currently, there is no method for recording payload data other than that provided by individual payloads. A third enhancement is ***the addition of two-way transfer of video with its associated audio and an interface with the audio and video subsystems.***

The Ku-Band Subsystem consists of the following ORUs: VBSP; High Rate Frame Multiplexer (HRFM); High Rate Modem (HRM); and the Antenna Group ORUs, which are the Transmitter/Receiver/Controller (TRC) and several antenna components. There is only one of each of the components. The VBSP, HRFM, HRM are located in the Lab Module. The Antenna Group is located on the Z1 truss. Figure 4-9 shows the route of the signal through the ORUs. Also, one interface to this subsystem not shown in Figure 4-9 is the GNC System. ***The GNC System provides data required for a backup method of antenna pointing in addition to providing initial pointing data for the autotracking method of pointing.***

The following subsections briefly discuss the components.

4.9.2.1 Video Baseband Signal Processor

The VBSP, shown with an interface with the VDS, converts the video signal from the fiber-optic format to a digital format to be processed by the Ku-Band Subsystem for transmission to the ground. ***The VDS selects and then sends to the VBSP up to four video signals for transmission***. After processing the video signals, the VBSP sends the video data to the HRFM.

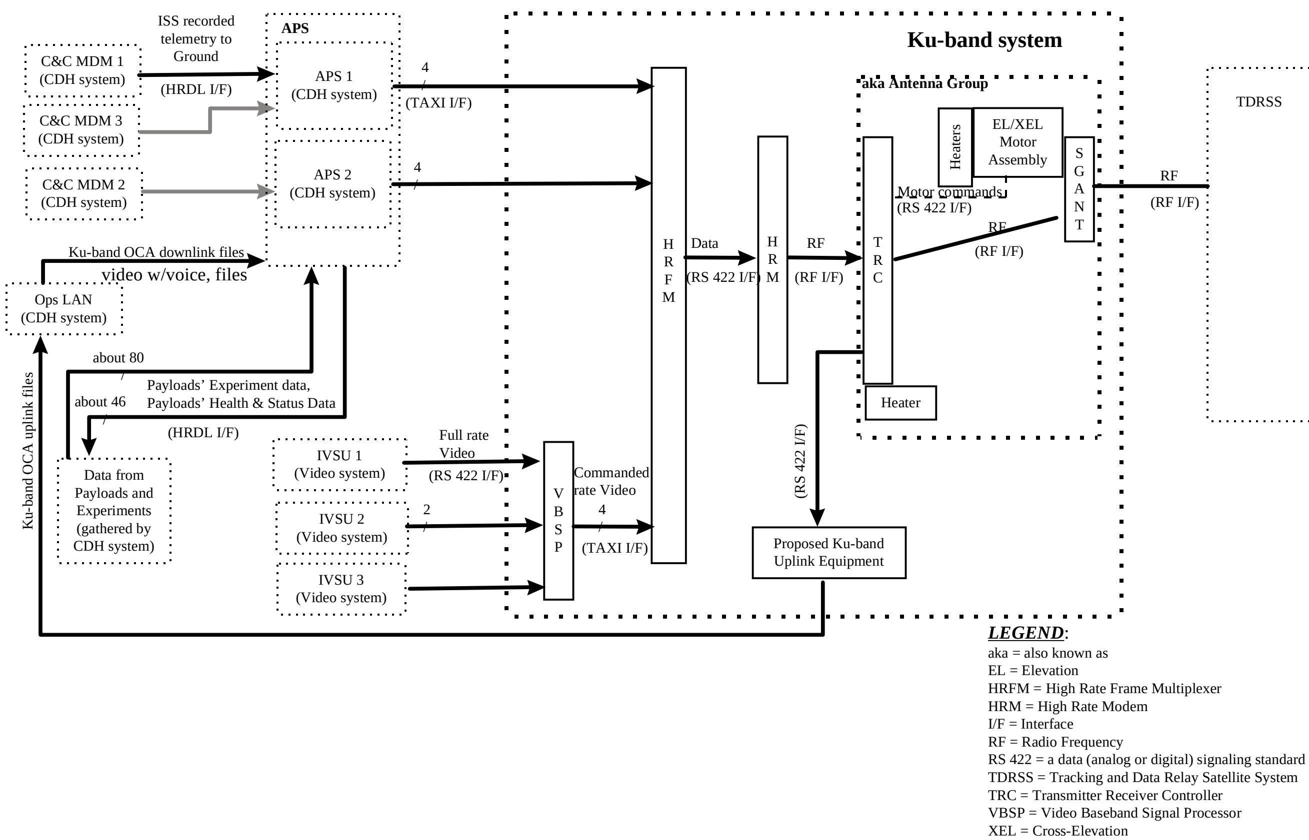

Figure 4-9. Ku-Band Subsystem

4.9.2.2 High Rate Frame Multiplexer

Note the interface between the HRFM and the Automated Payload Switches (APSs), which are ORUs in the CDH System. The APS multiplexes data from both payloads and the ZOE recorder (which provides recorded ISS systems telemetry) into eight channels. The HRFM accepts up to four channels of data from the VBSP and the ***eight channels of data from the APS***. ***The HRFM multiplexes, and R-S encodes these 12 together into one bit stream comprised of CADU-formatted data.*** The HRFM then sends the resulting baseband signal to the HRM.

4.9.2.3 High Rate Modem

The HRM modulates an RF signal and up-converts that signal to an Intermediate Frequency (IF). It sends this modulated IF signal to the Antenna Group ORUs.

4.9.2.4 Antenna Group

The Antenna Group up-converts the IF signal, amplifies it, and broadcasts the signal to the TDRS through the Ku-band directional gimbaled antenna. ***The Transmitter/Receiver/Controller (TRC) of the Antenna Group Assembly provides for "auto tracking," that is, the TDRS-received signal is used to point the antenna for broadcasting the return (downlink) signal.*** The TDRS transmits this data to the White Sands Ground Terminal for further distribution to ground facilities.

4.9.2.5 Application Software

The C&C MDM, through the Ku-band application software, controls and monitors the Ku-Band Subsystem. The C&C MDM sends commands to each component, and each component sends its status to the C&C MDM through the 1553 bus network. ***Since there is no redundancy in the subsystem, there can be no automatic switch to a redundant component or string.*** However, failures of individual data channels only impact those channels. Data on other channels can still be transmitted. Of course, while there is one 1553 bus connection to each ORU, there is dual redundancy in that each bus connection has two channels (A and B).

4.9.3 Russian Equivalent

The ROS Lira System provides two-way, high-speed radio communications with the ground through the Luch Relay Satellite System. The Lira System supports monochrome analog TV signal reception and simultaneous color and monochrome TV transmission using the PAL or SECAM formats. It transmits wide-band digital data, consisting of one of the following four combinations of information:

a. TV + voice + telemetry

b. TV + Continuous Data Steam (CDS) + telemetry

c. Digital voice + telemetry

d. CDS + telemetry

The Lira System can also transmit and receive digital data using the CDS format from/to the Regul Onboard System. Lira includes two transmitters and two receivers (one for course and one for fine direction finding) and a single modem. Transmission to and from the Luch System is through a 1.2-meter narrow beam antenna. Signal acquisition is accomplished by the use of omni-directional and semi-directional antennas.

Table 4-5 shows the expansion of the Ku-Band Subsystem capabilities during assembly of the ISS.

Table 4-5. Ku-band Subsystem assembly sequence

Flight	Hardware	Capability
3A	Ku-band antenna and transmitter/receiver on Z1 truss	External heaters with no telemetry. Heaters powered by one RPC
6A	Lab with Video Baseband Signal Processor, High Rate Frame Multiplexer, High Rate Modem. Planned Forward Receiver	Video downlink, payload experiment downlink, ZOE recorder downlink Two-way teleconferencing and file transfer to/from OPS LAN SSC/UCA equipment. Possibly, commanding

4.10 Summary

The C&TS is divided into six subsystems: the Internal Audio Subsystem (IAS), the S-Band Subsystem (S-band), the Ultrahigh Frequency (UHF) Subsystem (also known as the Ultrahigh Frequency Communication System (UCS)), the Video Distribution Subsystem (VDS), the Ku-Band Subsystem (Ku-band), and the Early Communication Subsystem.

The USOS C&T Subsystems work together to provide the communication services needed by the USOS to carry out the mission of the ISS. The S-Band Subsystem transmits voice, commands, telemetry, and files. The IAS distributes audio onboard the Station and to external interfaces. The VDS distributes video onboard the Station and to external interfaces, including the Ku-band for downlink. The UHF Subsystem is used for EVA and proximity operations, while the Ku-Band Subsystem is used for payload downlink and video and file two-way transfer.

Questions

1. Which of the following is <u>NOT</u> a part of a command path of the ISS?

    a. Regul

    b. S-band

    c. VHF

    d. UHF

2. U.S. Segment Video Subsystem receives a video input from the ROS Video Subsystem.
   a. True
   b. False
3. The S-Band Subsystem has an interface with the
   a. UHF Subsystem
   b. Audio Subsystem
   c. Video Subsystem
4. At Flight 8A, if the S-band string fails, which of the following is the <u>MOST</u> direct audio link to the ground?
   a. UHF Subsystem
   b. VHF System
   c. Ku-Band Subsystem
5. U.S. payload experiment data is transmitted to the ground by
   a. S-band
   b. Ku-band
   c. Regul
6. Which C&T Subsystem multiplexes video and payload data for transmission to the ground?
   a. S-band
   b. Ku-band
   c. Lira

7. The U.S. Subsystem that links the UHF and S-band Subsystems is

   d. Ku-band

   e. VDS

   f. IAS

8. What C&T Subsystem multiplexes audio and telemetry data for transmission to the ground?

   a. Ku-band

   b. S-band

   c. Lira

9. After 6A, recorded systems telemetry normally reaches the ground through which C&T Subsystem?

   a. Ku-band

   b. S-band

   c. UHF

   d. VDS

10. Primary commanding of the U.S. Systems is done through which C&T Subsystem?

    a. Ku-band

    b. S-band

    c. UHF

11. The VDS's most important interface for video data is with the

    a. IAS

    b. SSRMS

    c. CDH

12. C&W tones are sent to the ROS by the IAS.

    a. True

    b. False

13. The CDH OPS LAN receives forward link data from which ISS Subsystem.

    c. Ku-band

    d. S-band

    e. Lira

14. The Russian Segment Communication Subsystem that transmits using a high data rate is

    a. VHF1

    b. Regul

    c. Lira

15. What ROS Communication Subsystem cannot directly use the LUCH satellite?

    a. Lira

    b. Regul

    c. VHF2

16. What ISS Communication System is used to command the Station during orbiter rendezvous?

    a. VHF

    b. S-band

    c. UHF

17. The IAS distributes audio to the docked orbiter, EVA astronauts and _______________.

    a. Ku-band Subsystem

    b. Lira Subsystem

    c. Russian ACUs

18. Files can be received from the ground by which C&T Subsystem?

    a. VHF

    b. Ku-band

    c. UHF